

Letters to the Editor

Assessment of Toxicological Risks due to Hazardous Substances: Scoring of Risk Phrases*

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Recently, Landsiedel and Saling have described an interesting method for the assessment of toxicological risks for life-cycle assessment and eco-efficiency analysis [1]. In this letter we want to add some comments on this and similar approaches.

In many commercial and industrial production processes, substances and preparations are used which can extremely vary: organic and inorganic basic chemicals, additives, operating media, ancillary materials, catalysts. The products available for specific applications contain most different substances which can be problematic in terms of human toxicology or environmental impact. Life Cycle Assessment (LCA) studies often do not take into consideration the process chemicals used and their hazardous substance content.

Advances have recently been made concerning the impact assessment of the toxicity of chemicals [2,3]. Nonetheless, for several reasons, these advances currently cannot easily be applied for comparative product selection in companies. The number of substances already assessed is small compared to the total number of substances which are in use. Studies have focused on ecotoxicity, not on human toxicity. The assessment systems are highly complex. The terminology employed demands major efforts to be comprehended by non-experts in companies.

The approach [1] described by Landsiedel and Saling and the methodology of MEG equivalents [2,3] developed by our institute address some of the above-mentioned difficulties and offer possible solutions.

1 Scoring of Risk Phrases

Landsiedel and Saling propose a scoring system for assessing the toxic effects of chemicals ([1], Table 8, p. 266). The R-phrases describing the toxic properties of substances are divided into six groups. They are assigned a score between 100 and 1000. The higher the toxicity of the substance, the higher is the score.

This scoring system was based on a systematic survey of 42 people conducted by the authors for the assessment of 25 substances (27 staff members of the central product safety department of BASF, and 15 toxicology students at the Medical School of the University of Leipzig).

At the beginning of this year, Öko-Institut published a method in which the R-phrases are likewise used for an assessment of human toxicity [2,3]. In this case, mono ethylene glycol is additionally used as a reference substance for inventoring the use of hazardous substances. This allows the calculation of the hazardous substance potential for processes and products in life-

cycle assessments. This method, too, ranks the R-phrases. The basis for this ranking is a systematic comparison of the classification criteria for the R-phrases and the additional consideration of available air limit values. Commissioned by the German Federal Institute for Occupational Safety and Health (BAuA), the ranking system was proposed, intensively discussed and further developed by Kalberlah et al. The system has been included in the potency factor model published in the German Technical Rule for Hazardous Substances (TRGS 440).

Within this method, potency factors ('W') range from 0 to 50,000. Substances for which the health risk is known to be low have a potency factor $W = 0$, while substances with a proven high potential to cause chronic damage (e.g. carcinogenic and mutagenic substances) have a potency factor $W = 50,000$. The allocation table of potency factors to risk phrases taken from TRGS 440 is shown in Table 1.

Table 1: Allocation of risk phrases and substance properties to potency factors. Excerpt from the potency factor model of the German Technical Rule for Hazardous Substances (Technische Regel für Gefahrstoffe) 440 [2,3]

Risk-phrases and substance properties	Potency factor W
R45, R46, R49, M1, M2, K1, K2	50,000
R26, R27, R28, air limit value ¹⁾ < 0.1 mg/m ³	1,000
R32, R60, R61, RE1, RE2, RF1, RF2	
R35, R48/23, R48/24, R48/25, R42, R43	500
R23, R24, R25, R29, R31, R34, R41, H ²⁾	100
R33, R40, K3, M3, pH < 2 or > 11.5 ³⁾	
Not tested sufficiently and no air limit value	50
R48/20, R48/21, R48/22, R62, RE3, RF3	
R20, R21, R22	10
R36, R37, R38, R65, R67	5
R66, rated (but none of the stated criteria apply) or with air limit value ¹⁾ > 100 mg/m ³	1
Substances known to pose a low health risk	0

¹⁾ If the ambient air limit value is between 0.1 and 100 mg/m³, then $W = 100$ divided by the limit value

²⁾ With an 'H' rating in the German list of occupational exposure limit values (MAK-Liste) or TRGS 900 (the German Rule on ambient air limit values at the workplace), but no risk phrase. If one of the risk phrases 20, 21 or 22 applies, then the potency factor corresponding to that risk phrase is to be taken

³⁾ If $W < 100$ but the pH-value ≤ 2 or ≥ 11.5 , then W is set at 100, unless tested

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Table 2: Calculation of MEG equivalents for two wood preservatives

Product name	Hazardous constituents	Content	Risk phrases*	Meaning of risk phrases	Potency factor W
Aidol Carbolin	cristal oil 60	25%	R 65	Harmful: may cause lung damage if swallowed	5
	cristal oil 30	25%	R 65	Harmful: may cause lung damage if swallowed	5
	coconut fatty acid diethanol-amide	10%	R 36/38	Irritating to eyes / irritating to skin	5
	iso nonyl phenole, ethoxylated	2.5%	R 36/38	Irritating to eyes / irritating to skin	5
Aidol Carbolin, total hazardous substance content		62.5% 1 kg = 0.31 kg MEG equivalents			
Adolit CKO flüssig	chromium(VI) oxide	50%	R 25 R 35 R 43 R 49	Toxic if swallowed Causes severe burns May cause sensitizat. By skin contact May cause cancer by inhalation	100 500 500 50,000
	copper(II) oxide	14.4%	R 22	Harmful if swallowed	10
Adolit CKO fl., total hazardous substance content		64.4% 1 kg = 2,500 kg MEG equivalents			

*Here only those risk phrases referring to aspects of human toxicology are listed

2 MEG Equivalents as Indicators for the Use of Hazardous Substances

The MEG equivalents approach provides a refinement of the potency factor model that simplifies application and the presentation of results. Hazardous substances are compared with a reference substance. The reference substance chosen is mono ethylene glycol (1,2-ethanediol, glycol, CAS-No: 107-21-1), a liquid used, among other things, as an antifreeze agent and an organic basic chemical. Mono ethylene glycol (MEG) is toxic and labelled with the risk phrase 22 ('Harmful if swallowed'). The potency factor W of mono ethylene glycol (MEG) is 10.

Comparison of any individual substance to be assessed with MEG results for that substance in a weighting factor (characterisation factor). This weighting factor permits comparison or quantitative inventorisation of different substances – results are presented in a uniform manner by stating the MEG equivalent value. For preparations containing several hazardous substances, the procedure is the same.

3 MEG Equivalents for the Comparison of Products

The inventorisation of hazardous substances using MEG equivalents simplifies both the hazardous-substance-specific comparison of products and also the hazardous-substance-specific assessment of processes. The methodology of MEG equivalents and its application has already been published in detail [2,3]. At this point, therefore, only an example is to be shown in which the scoring of substances on the basis of their R-phrases and the calculation of the MEG equivalents are used for the assessment of hazardous-substance-containing process chemicals. Table 2 shows the calculation of the MEG equivalents for two wood preservatives.

These two wood preservatives have an almost identical overall hazardous substance content (63% and, respectively, 64%). However, their compositions differ greatly. Product 1 (Aidol Carbolin) contains substances with low hazards and correspondingly low potency factors. The hazardous substance inventory analysis thus arrives for the use of 1 kg Aidol Carbolin at an indicator value of 0.31 kg MEG equivalents. In product 2 (Adolit CKO flüssig), the health hazard is determined mainly by chro-

mium trioxide. It can cause severe burns, may cause cancer and sensitisation. The potency factor is correspondingly high, with a value of 50,000. This results for the hazardous substance inventory analysis in an indicator value of 2,500 kg MEG equivalents for the use of 1 kg Adolit CKO flüssig.

MEG equivalent values permit a first, simple comparison of products in terms of their workplace hazard potential. A precondition to this comparison is that the products are employed in comparable applications and processes.

Outlook

The publications on the toxicity assessment module by Landsiedel and Saling and on the use of MEG equivalents indicate interesting and similar approaches with regard to the consideration of toxicological risks within the framework of life cycle analyses. Both approaches are based on R-phrases which are available for many substances and are also specified in safety data sheets. There are differences concerning the method of allocating scores to R-phrases. For the methodology of MEG equivalents, the inclusion of upstream chains has been developed in a current project. The results will be published shortly.

References

The BASF toxicity assessment module was described in detail in [1]. The ranking of R-phrases according to TRGS 440, the methodology of MEG equivalents and their application were described in detail with the necessary references in [2,3].

- [1] Landsiedel R, Saling P (2002): Assessment of Toxicological Risks for Life Cycle Assessment and Eco-efficiency Analysis. *Int J LCA* 7 (5) 2261–2268
- [2] Bunke D, Graulich K (2002): Ein Indikator für den Einsatz gefährlicher Stoffe in Produkten und Prozessen: Monoethylenglykol-Äquivalente. UWSF – Z Umweltchem Ökotox, OnlineFirst, Dezember 2001. DOI: <http://dx.doi.org/10.1065/uwsf2001.12.081>
- [3] Bunke D, Graulich K (2001): MEG Equivalents as an Indicator of Hazardous Substance Use in Products and Processes. *Gate to Environmental Health Sciences: Life Cycle Management*, May 2002, p 1–9. DOI: <http://dx.doi.org/10.1065/ehs2002.05.015>